

graphical features, including but not limited to stems or horizontal segments. This is accomplished at runtime because the distances and dimensions of the characters are available in the CVT table.

For example, stems 209 of character 205 in FIG. 5a are inferred by determining that the black distances represented by arrows 211 alternate with the white distances from left-side bearing point 210 to point A and from point B to point C. It is also possible to use the grey distance indicated by arrow 213 instead of the white distance from point B to point C to infer the presence of a vertical stem.

In step 273, the DAG is traversed such that the stems may be phase adjusted or positioned on a high contrast pixel sub-component boundary. The first node of DAG 300 in FIG. 5b that indicates a stem is point A. The stem is moved such that the left edge of the stem falls on a high contrast boundary, such as the boundary between the green and blue pixel sub-components. Thus, the green pixel sub-component is exterior to the letterform and the blue pixel sub-component is interior to the letterform. In a similar manner, the other stems of a character are also hinted to a high contrast boundary.

One consideration that often arises when performing the hinting operations of the invention is adjusting for the potential error that the hinting process may introduce. As adjustments to the positions of the interdependent nodes are made as the DAG is traversed, the resulting placement of the right side bearing point of a character may become displaced. This error may also have an effect on the overall width of the character being rendered. However, the contrast of the character is improved. Thus, improved contrast may result in characters having erroneous overall widths, which may include a displaced right side bearing point.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:

1. In a computer system having a display device, the display device having a plurality of pixels each having a plurality of pixel sub-components of different colors, a method of adjusting image data to a grid defined by the pixels and pixel sub-components in preparation for rasterizing an image on the display device, the method comprising the steps for:

obtaining image data having selected control points with positions relative to the grid, the positions of at least one of the selected control points of the obtained image data not coinciding with a boundary between pixel sub-components;

hinting the image data such that a typographical feature defined by one or more of the selected control points is adjusted to a position on the grid that corresponds to a selected boundary between pixel sub-components, the selected boundary being designated as a high contrast boundary due to the color contrast of the sub-pixel components which define the boundary, and which may comprise a boundary other than one which is between pixels; and

displaying the image on the display device using the image data, the typographical feature being displayed at the high contrast boundary.

2. A method as defined in claim 1, wherein the image data represents a character, the method further comprising the step for analyzing the topology of the character at runtime to identify the typographical feature that is to be adjusted.

3. A method as defined in claim 1, wherein the step of displaying the image is conducted such that individual pixel sub-components of the pixels represent spatially different portions of the image data rather than the different portions being represented by entire pixels that include the individual pixel sub-components.

4. A method as defined in claim 1, wherein the typographical feature is a stem of a character represented by the image data.

5. A method as defined in claim 4, wherein the step for hinting the image data is conducted such that a left edge of the stem is aligned with the high contrast boundary.

6. A method as defined in claim 1, wherein the typographical feature is a horizontal segment of a character represented by the image data.

7. A method as defined in claim 1, wherein the step for hinting the image data comprising the acts of:

grid fitting the image data to grid points of the grid that corresponds to the pixels and pixel sub-components of the display device such that the one or more control points defined the typographical feature of the image data correspond to the grid points;

phase adjusting the typographical feature such that the typographical feature coincides with the high contrast boundary; and

interpolating the image data such that the position on the grid of remaining control points of the image data is adjusted.

8. A method as defined in claim 7, wherein the typographical feature is one or more vertical stems of a character.

9. A method as defined in claim 7, wherein the typographical feature is one or more horizontal segments of a character.

10. A method as defined in claim 7, wherein the image data represents a character to be displayed on the display device, the method further comprising analyzing the topology of the character at runtime to identify the typographical feature.

11. A method as defined in claim 7, wherein the act of phase adjusting further comprises the acts of:

analyzing hinting instructions associated with the image data for patterns that are indicative of the typographical feature;

deriving, from the hinting instructions, a directed acyclic graph, wherein the topology of the typographical feature is at least partially defined by one or more nodes of the directed acyclic graph; and

based on a traversal of the directed acyclic graph, identifying the position of the typographical feature and repositioning the typographical feature to the high contrast boundary.

12. A method as recited in claim 11, further comprising the acts of:

traversing the directed acyclic graph; and
encountering a node that corresponds to a point of the image data that is to be repositioned on the grid; and
accounting for an error introduced by a repositioning of a point corresponding to a previous node of the directed acyclic graph.

13. A method as defined in claim 11, wherein the act of analyzing the hinting instructions further comprises the act of searching for a selected pattern of distances having specified colors associated with the typographical feature.

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14. A method as defined in claim 13, wherein the selected pattern is a black distance surrounded by white distances.

15. A method as defined in claim 13, wherein the selected pattern is a black distance surrounded by grey distances.

16. A method as defined in claim 13, wherein the selected pattern is a black distance surrounded by distances that are not black.

17. A method as defined in claim 7, wherein the high contrast boundary is between a blue pixel sub-component and a green pixel sub-component, the blue pixel sub-component being interior to a character defined by the image data and the green pixel sub-component being exterior to the character.

18. A method as defined in claim 7, wherein the high contrast boundary is between a red pixel sub-component and a green pixel sub-component, the red pixel sub-component being exterior to a character defined by the image data and the green pixel sub-component being interior to the character.

19. A method as defined in claim 7, further comprising the act of mapping spatially different sets of one or more samples of the image data to individual pixel sub-components of the pixels rather than mapping samples to entire pixels.

20. A method as recited in claim 1, the image data being associated with a character, wherein the step for hinting the image data comprising the acts of:

analyzing the image data associated with the character, the image data defining:

an outline of the character using at least the one or more control points, distance between key control points; and a parent/child relationship of the key control points;

identifying distances of the character that are indicative of typographical features of the character to be positioned on high contrast boundaries, the identifying distances being associated with at least some of the key control points; and

positioning the identified key control points of the character to grid points on the grid that correspond to high contrast boundaries of pixel sub-components of the display device.

21. A method as defined in claim 20, wherein the distances include black distances which are interior to the outline of the character, white distances that are exterior to the outline of the character and grey distances which are a combination of black and white distances.

22. A method as defined in claim 20, wherein the distances define a stem width identified by the at least some of the key control points.

23. A method as defined in claim 22, further comprising the step of positioning the stems of the character.

24. A method as defined in claim 20, wherein the high contrast boundary is between blue pixel sub-components and green pixel sub-components, the blue pixel sub-components being interior to the character and the green pixel sub-components being exterior to the character.

25. A method as defined in claim 20, wherein the high contrast boundary is between red pixel sub-components and green sub-components, the red pixel sub-components being exterior to the character and the green pixel sub-components being interior to the character.

26. A method as defined in claim 20, further comprising the act of positioning the left character edge on the boundaries.

27. A method as defined by claim 1, the step for hinting the image data comprising the acts of:

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deriving a parent/child hierarchy representative of certain ones of said selected control points from the image data;

examining the image data for patterns that indicate typographical features, wherein the patterns are identified by the certain ones of said selected control points and each node of the hierarchy is associated with one of the typographical features; and

while traversing a data structure representing the hierarchy, phase adjusting one or more selected typographical features by positioning the certain ones of said selected control points associated with the selected typographical features on grid points of the grid that correspond to a high contrast boundary between pixel sub-components, the high contrast boundary not being a boundary between pixels.

28. A method as defined in claim 27, further comprising, as successive typographical features are phase adjusted, the act of accounting for an error introduced from phase adjusting the previous typographical feature.

29. A method as defined in claim 28, wherein the error is equal to the displacement of the previous typographical feature.

30. A method as defined in claim 27, wherein the pixel sub-components of the pixels are arranged on the display device to form vertical stripes of same-colored pixel sub-components and wherein the one or more selected typographical features include a vertical stem of the character.

31. A method as defined in claim 27, wherein the pixel sub-components of the pixels are arranged on the display device to form horizontal stripes of same-colored pixel sub-components and wherein the one or more selected typographical features include a horizontal segment of the character.

32. A method as defined in claim 27, wherein the patterns include alternating black and white distances, wherein the black distances include dimensions that are interior to the character and the white distances include dimensions that are exterior to the character.

33. A method as defined in claim 27, wherein the patterns include alternating black and grey distances, wherein the black distances include dimensions that are interior to the character and wherein the grey distances include dimensions that are both interior and exterior to the character.

34. A computer program product for implementing, in a computer system having a display device for displaying an image, the display device having a plurality of pixels, each pixel including a plurality of pixel sub-components, a method for hinting the image data in preparation for displaying the image data on the display device, the computer program product comprising:

a computer readable medium carrying computer executable instructions for implementing the method, the computer executable instructions, when executed, performing the acts of:

grid fitting the image data to grid points of a grid that corresponds to the pixel and pixel sub-components of the display device such that one or more control points defining a typographical feature of the image data correspond to the grid points;

phase adjusting the typographical feature such that the typographical feature coincides with a location of the grid that represents a boundary between pixel sub-components, the boundary being designated as a high contrast boundary due to the color contrast of the sub-pixel components which define the boundary, and which may comprise a boundary other than one which is between pixels; and

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interpolating the image data such that the position on the grid of remaining control points of the image data is adjusted.

35. A computer program product of claim 34, wherein the image data represents a character and, the method further comprising the acts of:

identifying selected points of the image data by examining dimensions and distances stored and associated with the image data; and

based on the examined dimensions and distances, recognizing the selected points as defined the typographical feature that is to be phase adjusted.

36. A computer program product as defined in claim 34, wherein the pixel sub-components are arranged on the display device to form vertical stripes of same-colored pixel sub-components, and wherein the typographical feature is a character stem that is parallel to the direction of the vertical stripes.

37. A computer program product as defined in claim 34, wherein the method further comprises the act of mapping spatially different sets of one or more samples to each of the pixel sub-components of a selected pixel, as opposed to mapping one or more samples to the entire selected pixel.

38. A computer program product as defined in claim 37, wherein the method further comprises the act of displaying the image on the display device based on the image data, resulting in the typographical feature being displayed at the high contrast boundary.

39. A computer program product as defined in claim 38, wherein the act of displaying the image on the display device comprises the act of separately controlling each of the pixel sub-components of the selected pixel by applying to the each of pixel sub-components of the selected pixel a luminance intensity value generated from the spatially different set of one or more samples mapped to the particular pixel sub-component.

40. A computer program product for implementing, in a computer system having a display device for displaying an image, the display device having a plurality of pixels, each pixel including a plurality of pixel sub-components, a method for hinting the image data in preparation for displaying the image data on the display device, the computer program product comprising:

a computer readable medium carrying computer executable instructions for implementing the method, the computer executable instructions, when executed, performing the steps for:

obtaining image data having selected control points with positions relative to the grid, the positions of at least one of the selected control points of the obtained image data not coinciding with a boundary between pixel sub-components;

hinting the image data such that a typographical feature defined by one or more of the selected control points is adjusted to a position on the grid that corresponds to a selected boundary between pixel sub-components, the selected boundary being designated

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as a high contrast boundary due to the color contrast of the sub-pixel components which define boundary other than a boundary between pixels; and

displaying the image on the display device using the image data, the typographical feature being displayed at the high contrast boundary.

41. In computer system having a processor and a display device having a plurality of pixels for displaying image data, each pixel having a plurality of pixel sub-components, a method for hinting the image data, the method comprising the acts of:

grid fitting the image data to grid points of a grid that correspond to the pixels and pixel sub-components of the display device such that one or more control points defining a typographical feature of the image data correspond to the grid points;

phase adjusting the typographical feature such that the typographical feature coincides with a location of the grid that represents a boundary between pixel sub-components, the boundary being designated as a high contrast boundary, the act of phase adjusting comprising:

analyzing hinting instructions associated with the image data for patterns that are indicative of the typographical feature;

deriving, from the hinting instructions, a directed acyclic graph, wherein the topology of the typographical feature is at least partially defined by one or more nodes of the directed acyclic graph; and

based on a traversal of the directed acyclic graph, identifying the position of the typographical feature and repositioning the typographical feature to the high contrast boundary; and

interpolating the image data such that the position on the grid of remaining control points of the image data is adjusted.

42. A method as recited in claim 41, further comprising the acts of:

traversing the directed acyclic graph; and

encountering a node that corresponds to a point of the image data that is to be repositioned on the grid; and accounting for an error introduced by a repositioning of a point corresponding to a previous node of the directed acyclic graph.

43. A method as defined in claim 41, wherein the act of analyzing the hinting instructions further comprises the act of searching for a selected pattern of distances having specified colors associated with the typographical feature.

44. A method as defined in claim 43, wherein the selected pattern is a black distance surrounded by white distances.

45. A method as defined in claim 43, wherein the selected pattern is a black distance surrounded by grey distances.

46. A method as defined in claim 43, wherein the selected pattern is a black distance surrounded by distances that are not black.

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